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EXPERIMENTS WITH TOXAPHENE AGAINST THE JAPANESE BEETLE

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Experiments have been carried on since 1947 to study the effectiveness of toxaphene in protecting plants from attack by adult Japanese beetles (Popillia japonica Newm.) and for controlling the larvae in the soil. In this study toxaphene has been compared with DDT.

Control of Adult Beetles

On July 14, 1947, in a generally infested orchard near Shiloh, N. J., five J. H. Hale peach trees were sprayed with toxaphene and five with DDT for control of adult beetles. The sprays contained 2 pounds of 50-percent wettable powder per 100 gallons of water. The remaining trees in the orchard were sprayed with other materials or left unsprayed. On an average 3 gallons of spray per tree was applied, with a small orchard sprayer.

Shortly after the spraying many dead and dying beetles were found beneath the trees treated with DDT, but only an occasional sickly beetle was seen beneath those sprayed with toxaphene. After 4 days no beetles were seen on the DDT-treated trees, but there were about half as many beetles on the trees sprayed with toxaphene as on the unsprayed trees. After 7 days there were no beetles on the trees treated with DDT, but there were about as many on those sprayed with toxaphene as on the unsprayed trees. This preliminary experiment demonstrated that, at the rate used, toxaphene was of little value in destroying an established infestation of beetles on peach trees, or in protecting the tree from subsequent infestation.

Toxicity to Larvae in Soil

A preliminary test was made to determine the relative toxicity of toxaphene and DDT to third-instar larvae. Each material was used as a 10-percent dust and inimately mixed with Sassafras sandy loam at

rates of 0.21, 0.42, 1.04, and 2.08 grams of the toxic ingredient per cubic foot, which was equivalent to mixing 5, 10, 25, and 50 pounds of the toxicants with the upper 3 inches of an acre of soil. For each treatment 300 third-instar larvae were introduced into six trays and maintained at a temperature of 80° F. At intervals of 2, 3, and 4 weeks the numbers of dead and living individuals were recorded. After each examination the living larvae were returned to the treated soils and the dead were discarded. The results are summarized in table 1.

Table 1.--Comparative toxicity of toxaphene and DDT to third-instar larvae of the Japanese beetle in Sassafras sandy loam

Dosage (pounds per acre)	Percent mortality of 300 larvae after--					
	Second week		Third week		Fourth week	
	DDT	Toxaphene	DDT	Toxaphene	DDT	Toxaphene
None	7		10		16	
5	30	29	45	40	55	49
10	54	70	78	88	91	97
25	93	89	99	98	99	100
50	97	99	100	100	100	100

The mortalities obtained with toxaphene and DDT at each rate of application were compared and analyzed by the chi-square method. In only one of the 12 comparisons of the two insecticides, 10 pounds during the second week, was there any significant difference in the mortalities. The results indicate that, pound for pound, toxaphene was equal to DDT in toxicity to the larvae.

Effectiveness in Different Soils

Toxaphene and DDT were applied as 10-percent dusts at the rate of 25 pounds of toxicant per acre and intimately mixed with 71 soils from Connecticut, Massachusetts, New Jersey, New York, North Carolina, Ohio, Rhode Island, and Virginia.[1/] One hundred and fifty third-instar larvae were introduced into each treated soil immediately after the

1/ The Agricultural Experiment Stations of Connecticut (New Haven), Massachusetts, Ohio, and Rhode Island cooperated by selecting and furnishing representative soils from their respective states.

toxicants had been applied and again 9 weeks later. The material was maintained at 80° F. in all of the laboratory tests here reported. Each type of soil was examined periodically and the numbers of dead and living individuals were recorded. After adjustment of the mortalities for the death rate in untreated soil, the number of days required to kill 98 percent of the larvae was determined. The results are summarized in table 2.

Table 2.--Comparative effectiveness of toxaphene and DDT in different soils at 80° F. when applied at the rate of 25 pounds per acre against third-instar larvae of the Japanese beetle

Soil type	Source	Average days required for 98 percent mortality	
		Toxaphene	DDT
Sands:			
Berrien	Ohio	14.0	9.5
Lakewood	N.J.	38.5	15.5
St. Johns	N.J.	17.5	18.5
Average		23.3	14.5
Gravelly and shale loams:			
Berks shale	N.J.	19.5	19.5
Lansdale gravelly	N.J.	18.5	16.0
Narragansett stony	R.I.	16.5	12.0
Penn shale	N.J.	11.5	23.0
Average		16.5	17.6
Sandy loams:			
Agawam	Conn.	19.0	19.0
Appling	N.C.	24.0	13.5
Bridgehampton	R.I.	19.5	14.0
Cecil	N.C.	9.0	10.5
Chenango	Ohio	14.5	11.0
Cheshire	Conn.	13.5	14.5
Collington	N.J.	18.0	18.5
Coloma	Mass.	35.5	14.5
Colts Neck	N.J.	14.0	16.5
Dover	Conn.	11.0	11.0
Dunellen	N.J.	31.5	17.0
Durham	N.C.	10.5	11.5
Hadley	Conn.	8.0	10.0
Helena	N.C.	7.0	9.0

Table 2. --Continued.

Soil type	Source	Average days required for 98 percent mortality	
		Toxaphene	DDT
Sandy loams (continued):			
Keyport	N.J.	16.5	24.5
Marlboro	N.C.	7.0	9.5
Merrimac	Conn.	15.5	15.5
	N.J.	19.0	23.0
Newfield	Conn.	11.0	11.5
Ondawa	Conn.	11.5	16.0
Painesville	Ohio	10.0	11.5
Penwood	Conn.	10.5	9.5
Plymouth	Mass.	56.0	34.5
Portsmouth	N.J.	37.0	26.0
Reynolds	N.C.	17.0	12.5
Sassafras	N.J.	9.0	16.0
Shrewsbury	N.J.	18.5	33.5
Wingdale	Conn.	11.0	13.0
Woodstown	N.J.	22.5	24.0
Average		17.5	16.4
Loams:			
Bernardston	R.I.	20.0	12.5
Brookfield	Mass.	14.5	14.5
Canadea	Ohio	10.5	11.0
Charlton	Conn.	19.0	14.5
Chenango	Ohio	12.5	11.0
Chester	N.J.	15.0	22.5
Collington	N.J.	13.5	25.0
Colts Neck	N.J.	8.0	21.5
Essex	Mass.	38.0	16.5
Gloucester	N.J.	19.0	23.0
Hartford	Conn.	14.5	10.5
Iredell	N.C.	9.5	10.5
Keyport	N.J.	15.0	20.5
Menlo	Conn.	56.0	39.5
Paxton	Mass.	21.0	16.5
Shrewsbury	N.J.	9.0	17.5
Washington	N.J.	13.0	18.0
Wethersfield	Conn.	11.0	9.5
Woodbridge	Conn.	45.0	18.5
Woodstown	N.J.	18.0	23.0
Average		19.1	17.8

Table 2. --Continued.

Soil type	Source	Average days required for 98 percent mortality	
		Toxaphene	DDT
Silt loams:			
Croton	N.J.	14.5	27.5
Elkton	N.J.	19.0	24.5
Georgeville	N.C.	12.0	14.5
Hagerstown	N.J.	16.0	16.5
Lansdale	N.J.	13.5	17.0
Mentor	Ohio	9.0	10.0
Painesville	Ohio	12.5	8.5
Penn	N.J.	17.5	23.0
Pittsfield	N.Y.	23.0	14.5
Whippany	Conn.	7.5	10.0
Wooster	Ohio	9.0	12.0
Average		14.0	16.2
Silty clay loams:			
Lorrain	Ohio	31.0	15.0
Mahoning	Ohio	9.0	9.5
Average		20.0	12.3
Davidson clay loam	N.C.	10.5	11.0
Muck	Va.	40.5	30.0
General average		17.9	16.7

Least significant difference between toxaphene and DDT treatments:

In all soils	1.7	In all loams	3.2
In all sands	8.2	In all silt loams	4.3
In all gravelly and shale loams	7.1	In all silty clay loams	10.0
In all sandy loams	2.6	In individual soils	14.2

The analysis of the variance in mortality showed that there were highly significant differences between soils in the speed of insecticidal action, but the average speed of toxaphene was not significantly different from that of DDT. The differences required for significance between the treatments in various soil types and in individual soils were determined from the pooled standard deviation obtained in the analysis of the variance.

The average rates of insecticidal action were not significantly different in the sands, gravelly and shale loams, sandy loams, loams, silt loams, silty clay loams, and clay loams, but there was definitely more variation in the speed of insecticidal action in the individual soils with toxaphene than with DDT. The standard deviation with toxaphene was 12.0 days, but it was only 7.4 days with DDT. The rate of insecticidal action with toxaphene appeared to be significantly slower than that with DDT in 8 of the soils--Lakewood sand, Coloma sandy loam, Dunellen sandy loam, Plymouth sandy loam, Essex loam, Menlo loam, Woodbridge loam, and Lorrain silty clay loam; significantly faster in 1 soil--Shrewsbury sandy loam; and not significantly different in 62 soils.

Effect of Organic Matter and Fertilizers

The speed of insecticidal action was definitely slower in soils relatively high in organic matter, as in Menlo loam and muck, an indication that the organic matter was an important factor. In a further study of the influence of organic matter, toxaphene at the rate of 25 pounds per acre was applied to mixtures of Sassafras sandy loam and finely divided peat. One hundred and fifty larvae were introduced into each mixture immediately after it had been treated (test 1) and again 9 weeks later (test 2). The results of these tests are summarized in table 3. An analysis of variance showed that the addition of the peat modified very significantly the speed of the insecticidal action. The retardation in this speed increased progressively with the increment in the amount of organic matter.

Table 3.--Effect of organic matter (peat) in Sassafras sandy loam on the speed of insecticidal action of toxaphene against third-instar larvae of the Japanese beetle

Percent (by volume) of peat	Days required for 98 percent mortality		
	Test 1	Test 2	Average
0	7	8	7.5
25	7	23	15.0
50	11	24	17.5
75	11	29	20.0
100	12	41	31.5

Tests were also made to determine the effect of various fertilizers and soil conditioners on the speed of insecticidal action with toxaphene There was no indication that applying 4,000 pounds of hydrated lime per acre, or 1,000 pounds of aluminum sulfate, ammonium phosphate.

calcium sulfate, ferrous sulfate, potassium phosphate, potassium nitrate, or sulfur, had any effect on the toxaphene. Three commercial mixed fertilizers applied at the rate of 2,000 pounds per acre also had no effect on the toxicant.

Control of Larvae in Turf

In the spring of 1947 toxaphene and DDT were applied at the rate of 25 pounds per acre to 1/4-acre plots of turf at Blairstown, N.J., and at Orange and New London, Conn., for control of larvae. Both materials were applied as 10-percent dusts by means of a 3-foot fertilizer spreader. The grass on the golf course at Blairstown was relatively fine and closely mowed, but on the parkways at Orange and New London it was coarse and not closely mowed. At New London particularly, the grass tended to form a mat at the soil surface.

Surveys were made periodically to determine the effect of the treatments on the larvae. Fifteen 1-square-foot diggings were made at random in each plot, and an equal number were made in untreated turf in the vicinity of each plot. These surveys were omitted in Connecticut during the fall of 1948 and of 1949, because the dry weather had reduced the population of larvae to such a low level that a valid appraisal of the treatments could not be made. The results obtained with these treatments are summarized in table 4.

Table 4.--Comparative effectiveness of toxaphene and DDT applied at the rate of 25 pounds per acre for the control of Japanese beetle larvae in established turf

Location of plots	Weeks after treatment	Brood of Popillia	Population per square foot in untreated area	Apparent reduction (percent)	
				Toxaphene	DDT
Blairstown	4	1946-47	15	68	78
	17	1947-48	19	97	99
	55	1947-48	6	100	100
	72	1948-49	5	100	100
	121	1949-50	5	100	100
	173	1950-51	14	100	100
Orange	4	1946-47	8	69	75
	17	1947-48	24	98	99
	54	1947-48	16	100	100
	173	1950-51	7	98	100
New London	4	1946-47	11	30	10
	17	1947-48	7	48	55
	54	1947-48	6	98	79
	173	1950-51	4	100	100

Neither treatment had much effect on the 1946-47 brood at New London. Both treatments caused only a partial reduction of the 1947-48 brood before pupation, but eliminated the 1950-51 brood by mid-September. It is possible that the coarse, tough turf in this locality delayed the penetration of the toxicants into the soil to such an extent that more than a year elapsed before satisfactory control was obtained.

Growth of Plants in Soils Containing Toxaphene

Since 1947, when toxaphene was applied to turf on the golf course at Blairstown, N. J., and to the coarser grasses in the plots in Connecticut, there has been no gross indication that the treatment has affected the growth of the grasses.

To obtain some more definite information on the reaction of plants to toxaphene in the soil, seeds of some common vegetables were sown in the greenhouse in soil treated with toxaphene at rates of 10, 25, and 50 pounds per acre, and also in untreated soil. There was no indication that the toxaphene modified the germination. After the seedlings were a few inches high, they were thinned to 10 plants of each variety in each treated soil and in the untreated soil. When the plants had grown 2 to 3 months, they were cut at the surface of the ground and the green weight of each plant was determined.

As these tests were preliminary and not replicated, only a gross effect on the plants would have any significance. No serious deleterious effect was observed on Bountiful bean, Calabrese broccoli, Chinese cabbage (Chihli), Globe cabbage, Old Hickory corn, Scotch Dwarf Blue kale, Big Boston lettuce, Early Red radish, Long Cocozelle squash, or Purple-top White Globe turnip. Cucumbers of the A. and C. variety failed to grow in soil treated with toxaphene at the rate of 25 or 50 pounds per acre. Black Beauty egg plant, New Jersey Worldbeater peppers, and Garden State, Marglobe, and Rutgers tomatoes were retarded by the application of 50 pounds of toxaphene per acre.

Summary and Conclusions

In experiments begun in 1947 for the control of adult Japanese beetles (Popillia japonica Newm.) and for controlling larvae in the soil, toxaphene appeared to be of little value for destroying an infestation of adult Japanese beetles on peaches at Shiloh, N. J., or in protecting the trees from subsequent infestation.

In laboratory tests toxaphene and DDT were of the same order of toxicity to the third-instar larvae when mixed with 71 representative soils from Connecticut, Massachusetts, New Jersey, New York, North Carolina, Ohio, Rhode Island, and Virginia. The insecticidal action was retarded by organic matter in the soil, but was not affected by applications of the common fertilizers.

Since 1947 equally good results have been obtained with toxaphene and DDT in controlling infestations of larvae in turf in Connecticut and New Jersey, when the toxicants were used at the rate of 25 pounds per acre.

Toxaphene caused no damage to established turf. Preliminary tests with some of the vegetables indicated that the growth of eggplant, peppers, and tomatoes was retarded by an application of 50 pounds of toxaphene per acre. Cucumbers failed to grow in soils containing 25 or 50 pounds per acre.

In conclusion, the preliminary tests with toxaphene indicate that it is of little value in protecting plants from attack by the adult Japanese beetle, but it may have a place in the control of the larvae in the soil.